Assessment of the Potential Costs and Energy Impacts of Spill Prevention, Control, and Countermeasure Requirements for Electric Utility Substations

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By

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Electric Utility Substations[1]

1. Sector Description

Affordable and reliable electricity is critical to the U.S. economy and represents roughly 4% of the nation's gross domestic product. Since 1960, the amount of electricity consumption per dollar of real GDP has increased by more than 25%, while the amount of overall energy use has decreased by more than 40% (EEI 2005a).

There are more than 3,170 traditional electric utilities in the United States responsible for ensuring an adequate and reliable source of electricity to all consumers in their service territories at a reasonable cost. These utilities include investor-owned, publicly owned, cooperative, and Federal utilities. Power marketers[2] are also considered electric utilities. Utilities are regulated by local, State, and Federal authorities.

In 2004, net generation produced by electricity utilities was about 2,500 billion kilowatt hours and total generating capacity was about 550 gigawatts. There are also about 2,100 nonutility power producers,[3] which produced about 1,500 billion kilowatt hours (EIA 2006).

1.1 Utility Substation Description

Delivery of electricity to consumers requires power generation, transmission, and distribution. Electric utility substations are used in transmission and distribution and operate independently of the fuel used to generate the electricity. A typical substation facility consists of a small building with a fenced-in yard containing transformers, switches, voltage regulators, and metering equipment used to adjust voltages and monitor circuits. Power leaves the generator and enters a transmission substation, where large transformers convert the generator's voltage to extremely high voltages (155kV to 765 kV) for long-distance (up to about 300 miles) transmission. Power comes off the transmission grid at distribution substations where the voltage is stepped-down (typically to less than 10kV) and carried on smaller distribution lines for delivery to commercial, residential, and industrial users. There are an estimated 100,000 substations in the United States.

[1] This paper addresses electric utility substations and the secondary containment provisions in the SPCC rules. A separate paper on electric utilities addresses underground storage tanks at nuclear power plants. Another paper addresses wind turbines.

[2] Power marketers are entities that buy and sell electricity, but usually do not own or operate generation, transmission, or distribution facilities.

[3] Non utilities include small power producers, cogenerators, and independent power producers. Total capacity (including independent power producers and cogenerators) was about 963 gigawatts.

1.2 Sector Economics

Estimated construction expenditures in 2004 for transmission and distribution were $17.7 billion (EEI 2005b). On an annual basis, roughly $6 billion is for new substation construction. The costs for substation construction depend on numerous factors including type, size, and location. Transformers are the primary cost components, with the higher voltage-rated transformers having the higher costs. A 1997 study indicated that a 500kV transformer would cost nearly $3 million. The same study provided a range in costs for 21 substations of $208,000 for a substation with one 69kV transformer to $21,715,000, for a substation with one 500kV transformer, three 161 kV transformers, and three 15kV transformers (Dagle and Brown 1997).

2 Substations and the SPCC Rules

2.1 Substation Operations Affected by the SPCC Regulations

The operations within the electric utility sector that are most affected by the SPCC regulations in terms of energy impact are the substations (and in particular, the transformers at these substations). Transformers do not store oil. Rather, they use oil to cooling and insulation needed for the equipment to function.

Substation equipment falls into the category of "oil-filled equipment" under the 2002 rules and "oil-filled operational equipment" under the 2005 proposed revisions. The 1973 rules contain no specific mention of substations or other equipment that uses rather than stores oil. Thus, industry and the regulatory agencies operated under the assumption that the 1973 rules were aimed at storage tanks and not equipment that used oil in operations. A discussion of the applicability of the 1973 SPCC rules to electric and operating equipment is available in industry comments to EPA on EPA's proposed 2005 revisions to the SPCC rule; Attachment 1 is an excerpt from those comments.

The table below presents, for various iterations of the rule, the estimated coverage of substations that would be subject to the SPCC requirements and the specific portions of the rule that result in energy impacts.

Under the 2002 rules, all substations with more than 1,320 gallons that could discharge oil in harmful quantities to navigable waters are subject to the rule. Because most substations have more than 1,320 gallons, those substations that could discharge oil in harmful quantities to navigable waters would qualify. No one knows the number of substations that would meet this potential discharge criterion, but the utility industry estimates the number to be between 50,000 and 80,000 (Roewer 2006).

2.2 SPCC Compliance Requirements for Substations

The most significant SPCC requirements for substations are the secondary containment requirements in the 2002 rule. As noted above, the 1973 rules were not believed to apply to substations, and the 2005 amendments offer a less costly — and much less energy impacting —

Application of SPCC Regulations to Substations*

	1973 Rule	2002 Rule	2005 Proposed Amendments
Does the SPCC rule apply to substations?	No. § 112.1(b) states that the rule "applies to owners or operators of non-transportation-related onshore and offshore facilities engaged in drilling, producing, gathering, storing, processing, refining, transferring, distributing or consuming oil and oil products, and which, due to their location could reasonably be expected to discharge oil in harmful quantities, as defined in Part 110 of this chapter into or upon the navigable waters of the United States or adjoining shorelines." The 1973 rule refers to tanks and containers; it does not refer to equipment that uses oil as being subject to the rule.*** The closest reference is in the definition of (1) "Non-transportation-related onshore - and offshore facilities," which includes oil production, refining, and storage facilities, pipelines, loading racks, certain vehicles, and "Industrial, commercial, agricultural or public facilities, which use ***and*** store oil, but excluding any terminal facility, unit or process integrally associated with the handling or transferring of oil in bulk to or from a vessel." Neither the preamble nor the rule refers to oil-filled, electrical, or any other type of equipment except for equipment associated with oil production and storage or for containment.	Yes. § 112.1(b) states that the rule "applies to any owner or operator of a nontransportation-related onshore or offshore facility engaged in drilling, producing, gathering, storing, processing, refining, transferring, distributing, ***using***, or consuming oil and oil products, which due to its location, could reasonably be expected to discharge oil in quantities that may be harmful, as described in Part 110 of this chapter, into or upon the navigable waters of the United States or adjoining shorelines."** The preamble says that a facility using oil may reasonably be expected to discharge oil and therefore, the prevention of discharges from such facility falls within the scope of the statute. However, EPA distinguishes the bulk storage of oil from the operational use of oil. ''Bulk storage container'' in the 2002 rules mean any container used to store oil. EPA specifically excluded oil-filled electrical, operating, or manufacturing equipment from the definition of bulk storage.	Yes. The amendments make no changes to § 112.1 (b) in the 2002 rule.

	1973 Rule	2002 Rule	2005 Proposed Amendments
Under what category are substations included?	Substations not included.	"Oil-filled equipment." The rule does not define oil-filled electrical, operating, or manufacturing equipment. However, the preamble states (67 FR 47080) that examples of operating equipment containing oil include electrical equipment such as ***substations***, transformers, capacitors, buried cable equipment, and oil circuit breakers.	"Oil-filled operational equipment." The proposed amendments add a definition for oil-filled operational equipment. "Oil-filled operational equipment" means equipment which includes an oil storage container (or multiple containers) in which the oil is present solely to support the function of the apparatus or the device. Oil-filled operational equipment is not considered a bulk storage container, and does not include oil-filled manufacturing equipment (flow-through process) (70 FR 73550).
What is the minimum amount of oil that must be stored in above-ground containers for the facility to be subject to the rules?	1,320 gallons, in aboveground containers, with no single tank larger than 660 gallons.	1,320 gallons, in aboveground containers (removed single tank threshold).	1,320 gallons for SPCC plan preparation, but no threshold for proposed alternative requirements for secondary containment.
Are ***all*** substations subject to the SPCC rule?	Substations not included.	Theoretically, No. Only those that store or use more than 1,320 gallons and that due to their location, could reasonably be expected to discharge oil in quantities that may be harmful into or upon the navigable waters of the United States or adjoining shorelines* (§112.1(b)). However, because substations generally exceed the 1,320-gallon threshold and could be considered to be in a location that meets the navigable water criterion, the majority of substations will, in practice, be subject to the rule.	Same as 2002 rule.

	1973 Rule	2002 Rule	2005 Proposed Amendments
What SPCC regulatory requirement(s) for substations result in energy impacts?	None; SPCC rules do not apply to substations	Secondary containment for onshore facilities as described in §112.7(c): Owner/operators must "Provide appropriate containment and/or diversionary structures or equipment to prevent a discharge as described in §112.1(b). The entire containment system, including walls and floor, must be capable of containing oil and must be constructed so that any discharge from a primary containment system . . . will not escape the containment system before cleanup occurs.	Secondary containment if implemented, but the new § 112.7(k) offers an alternative for "qualified oil-filled operational equipment." To be qualified, the substation must be at a facility that has had no discharges from "oil-filled operational equipment" in the past 10 years, or, if the facility has not been operational for 10 years, in the years since it has been operational (§ 112.7 (k)(1)). The alternative to general secondary containment is that the owner/operator must: (i) establish and document facility procedures for inspections or monitoring to detect equipment failure and/or a discharge; and (ii) (Unless a response plan under § 112.20 has been submitted) provide an oil spill contingency plan and a written commitment of manpower, equipment, and materials required to expeditiously control and remove any quantity of oil discharged that may be harmful.

* The italicizing of certain words in this table has been done by the author for emphasis.

** or into or upon the waters of the contiguous zone, or in connection with activities under the Outer Continental Shelf Lands Act or the Deepwater Port Act of 1974, or that may affect natural resources belonging to, appertaining to, or under the exclusive management authority of the United States (including resources under the Magnuson Fishery Conservation and Management Act) (§112.1 (b)).

*** See discussion of applicability to 1973 rule in Attachment 1

alternative to secondary containment. For substations in locations that could reasonably be expected to discharge oil in quantities that may be harmful into the navigable waters of the United States, the 2002 rules require operators to retrofit existing substations with secondary containment and to install secondary containment in new substations.

3 Potential for Energy Supply Disruptions from SPCC Requirements at Substations

Potential supply disruptions associated with installing secondary containment may result from the increased investment costs to retrofit existing substations with secondary containment and the potential for outages during construction of that containment.

3.1 Costs for Retrofitting

The electric utility industry estimates capital costs for installing general containment (e.g., berms, dikes, retaining walls, retention ponds) at existing substations to be $30,000 to $60,000 per facility. The physical area of a given substation, the shell volumetric capacity of the devices within the substation, and overall design (overhead clearances, etc.) in the substation could cause these costs to increase. If "sized" containment is required (e.g., concrete or other containment basins to make it "sufficiently impervious"), these costs will increase. Costs will be higher (about $200,000 per substation) for larger facilities where moving large transformers and repositioning them and removing and replacing extensive overhead bus infrastructure would be required.

Assuming an average cost to retrofit a substation with secondary containment of $45,000, and a midpoint of 65,000 substations requiring retrofit, compliance costs for retrofitting existing substations with secondary containment would be roughly $3 billion. Assuming all these costs are incurred in one year (which would be realistic to meet the compliance schedules), the costs would be nearly half of what is typically spent in a year for new substation construction. It would also be equivalent to about 1.5% of total electric utility revenues, which were about $216 billion in 2004. These compliance costs are high enough to cause energy supply disruptions for consumers in at least two different ways.

First, while 1.5% of revenues may not seem to be a significant impact at the national level, these costs may not be spread evenly across all users. Instead, certain locations may require more substation retrofits than others. Such locations would be those with relatively higher numbers of substations, and with most if not all of these substations located near navigable waters. If these areas are near urban population centers, adding the secondary containment installation costs to the rate base will be felt by consumers of all income levels, and those at the lower ends may be forced to choose between using the amount of electricity that they may want and other items (such gasoline for transportation and fuel to heat their homes), which are increasing in cost for reasons unrelated to spill prevention.

Second, if the utilities cannot recover the estimated $3 billion immediately, they will need to postpone other capital investments that would otherwise have been undertaken with the money used for secondary containment. These capital investments

would likely include new substation construction, improvements to the infrastructure needed to ensure delivery during peak loads and severe weather conditions, investment to meet environmental protection requirements (e.g., replacing treated utility poles), and other investments needed to meet the increasing electricity demands by users.

Costs for incorporating containment into new substations. The estimated cost to incorporate secondary containment and design into a new substation is about $100,000. Because there are relatively few new substations constructed in a given year, the overall costs of installing containment at new substations is not expected to cause significant cost impacts at the national level. However, if such new construction were to occur in the same area as the retrofits, these costs may exacerbate the increased costs due to retrofitting.

3.2 Potential for Outages During Construction

The utility industry estimates that installing secondary containment at an existing substation, would require the substation to be removed from service for about 2 to 4 weeks. During that time, consumers (and other downstream substations) that would have otherwise been serviced through that substation will need to obtain their electricity from other sources. Technically, this is not a difficult issue. Using alternate feeds is required when substations are down for scheduled maintenance or in cases of unexpected outages due to weather conditions or other overloads. However, removing a substation from service for 2 to 4 weeks to install secondary containment adds strain to the system and would exacerbate the supply disruptions that could occur if one or more external events caused outages in the grid. If a large station were undergoing a retrofit and back up were lost, there would be a chain of downstream substations customers that could be without electricity for an undetermined amount of time.

Compounding the potential energy impact of outages for containment installation is the general need for substation upgrades unrelated to spill prevention. Substation transformer failures are projected to increase significantly over the next ten years as many units installed in the 1950s and 1960s exceed their operational life cycle. Upgrading these facilities and building new units will put additional strains on system deliverability.

Also, some rural areas have substations with no backup feed from the grid. Removing these substations from service could require the importation of a mobile transformer (with no additional backup) to meet the user needs during the time of containment construction. Should the mobile transformer fail, these users would be without electricity.

Because of the potential for increased loads, it may be difficult to schedule shut downs during peak summer loads, meaning that most if not all shutdowns would need to occur during other times of the year, putting additional strain on the system during those periods and making a one-year compliance schedule difficult to meet.

Retrofitting may have other unintended consequences that could prolong the outage and exacerbate the strain on the power system. For example, during excavation, cables could be cut that would need to be replaced, or other accidents with similar repercussions could occur.

Although these shutdowns would be temporary, any disruption in electricity delivery would have major impacts on commercial, industrial, and residential users. The potential for such disruptions and their impacts should be weighed against the benefits of installing secondary containment. These benefits would presumably be to reduce the risks of spills reaching navigable waters, but according to EPA data, the risk of a spill from oil-filled operating equipment is orders of magnitude less than that from a tank (USWAG 2001). (See risk discussion below.)

Another potential unintended consequence of installing secondary containment is the increased potential for catastrophic fires. Despite established safeguards, significant fires at substations have occurred. A portion of substation transformer failures occur in an "eventful mode," leading to ruptures and/or fires. The purpose of containment is to prevent oil from migrating offsite and to navigable waters. Concrete, clay liners, and related materials are effective for containing the oil, but at the same time, a leak that is contained in these basins increases the potential for fire that may be difficult to contain. Such fires can remove the substation from service for an extended period of time and cause damage to nearby (non-utility) property and equipment, casualties, and resulting liabilities. Two recent transformer substation fires, one at a nuclear power plant and one at a petrochemical plant, resulted in production downtime that lasted weeks and was estimated to cost roughly $1 million per day for each incident (McShane 2003).

4 Risks

DOE understands that the SPCC rule are not risk-based. However, it believes that the costs and potential energy impacts associated with installing secondary containment at substations do not appear to warrant the very small, if any, reduction in risks that would be provided. Transformers and other substation equipment are designed for different purposes than storage and have much lower potential to leak. As reported by USWAG, the cooling, insulating, and or lubricating oils in substation equipment are intrinsic to and facilitate operation of the equipment. Oil-filled equipment is designed, constructed, and maintained according to specifications for its particular operation, and construction materials are corrosion-resistant. A leak is readily detected and remedied. Oil-filled operational equipment typically has minimal oil throughput, because frequent transfers of oil are not required. By contrast, transfers of oil into bulk storage containers are commonplace and a frequent cause of oil spills.

5 Mitigating Options

EPA has proposed an alternative to the 2002 rules that would reduce energy impact, while providing the same level of spill prevention and control. If the proposed revisions as detailed in the December 2005 proposed amendments were implemented as written, they would provide a rational balance between achieving the SPCC objectives and avoiding electricity shortages and increased costs to consumers; that is they would minimize energy impact and meet spill prevention objectives.

References

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Attachment I
Excerpts from USWAG's February 10, 2006 Comments on EPA's Proposed 2005 Amendments Regarding Regulation of Oil-Filled Equipment (USWAG 2006)

Until EPA promulgated the 2002 SPCC amendments (67 Fed. Reg. 47042 (July 17, 2002)), the electric utility industry did not believe the SPCC rules applied to electrical equipment. Neither the text of the original 1973 SPCC rules nor the preamble to those rules mentioned oil-filled equipment as part of the regulated universe. See 38 Fed. Reg. 34165 (Dec. 11, 1973). The trigger for regulation in 40 C.F.R. § 112.1(b) described a range of activities typical of oil storage and production facilities but atypical of electrical equipment installations. Unlike the oil in storage tanks, electrical equipment does not store oil but uses oil operationally to provide cooling and insulation, a fact EPA acknowledged in its 1991 proposed amendments. See 56 Fed. Reg. 54612, 54623 (Oct. 22, 1991). Indeed, the belief that SPCC regulation did not extend to electrical equipment was apparently shared by some EPA staff because the Agency's own Economic Impact Analysis prepared in conjunction with the 1991 proposed SPCC amendments omitted electrical equipment in its calculation of the burdens imposed by the SPCC regulations.[4]6 That omission was not remarkable because only three years earlier EPA had explicitly excluded electrical equipment, hydraulic lifts, and other equipment that utilizes oil operationally from its 1988 underground storage tank ("UST") regulations because the equipment is self-monitoring and experience had shown a much lower risk of discharge from this equipment in comparison with the tank universe that was the obvious concern of the UST program. 40 C.F.R. § 280.10(b)(3); see 53 Fed. Reg. 37082, 37111-12 (Sept. 23, 1988).

Given the Agency's silence on oil-filled equipment in its 1973 SPCC rulemaking, its omission of electrical substations from its 1991 impact analysis, the positive environmental experience with this electrical equipment in contrast to the bulk storage tank and container universe, and the absence of any enforcement cases involving claims of noncompliance with SPCC requirements by facilities with such equipment for nearly a quarter century after the SPCC rules were promulgated, the industry had a reasonable basis for concluding that the original 1973 SPCC rules did not extend to oil filled equipment.

We are troubled that EPA asserts in the preamble to the proposed amendments that oil-filled equipment were subject to SPCC regulation prior to the 2002 amendments. See 70 Fed. Reg. at 73534, 73545. EPA describes the 2002 amendments as having "clarified" the regulatory status of oil-filled equipment (id. at 73534), but that rule did much more than clarify existing regulatory language. The 2002 amendments added an entirely new activity when it added the term "using" to the list of activities in section 112.1(b) that trigger the applicability of SPCC

[4] The 1991 analysis estimated approximately 4600 to 4800 electric utility facilities subject to SPCC regulation. Economic Impact Analysis of the Proposed Revisions to the Oil Pollution Prevention Regulations, Docket No. SPCC-1P-7-4.2 at 3-15 & 3-25 (Jan. 1991). This estimate reflected the number of SPCC-regulated facilities at generating stations, service centers, and a few transmission and distribution facilities. If EPA had included oil-filled equipment within the SPCC-regulated universe, the estimated number of SPCC-regulated facilities in the utility industry would have totaled approximately 100,000.

regulation.[5] Moreover, as an expansion of the SPCC rules, compliance with the regulations is part of the deferral that EPA proposes to extend to October 31, 2007. See id. at 73518.

Ultimately, the issue of the scope of the 1973 rules is essentially one of fair notice. Where (1) none of the rulemaking indicators (i.e., text, preamble, economic impact analysis) mentioned oil-filled equipment, (2) the regulatory requirements were not tailored to the unique characteristics of the equipment, (3) the environmental experience has been significantly more favorable than the obvious target of the regulation, and (4) the Agency's enforcement policy over many years shows a lack of interest in the equipment, it made no sense for the industry to assume that its equipment was subject to the burdens of the SPCC program. Regulatory silence cannot be the basis for sweeping a large universe of equipment into a costly regulatory program largely designed to deal with very different oil-storage containers. As the Supreme Court recently cautioned in an analogous context where a party claimed profound changes to a complex regulatory scheme based on ambiguous statutory language:

Congress, we have held, does not alter the fundamental details of a regulatory scheme in vague terms or ancillary provisions—it does not, one might say, hide elephants in mouse holes. Whitman v. American Trucking Ass'ns, Inc., 531 U.S. 457, 468 (2001). Accord, Gonzales v. Oregon, 546 U.S. ___, 126 S. Ct. 904, 921 (Jan. 17, 2006). The same principle holds true in interpreting the scope of agency regulations.

[5] Prior to amending the rule in 2002, the list of activities that triggered regulation read as follows: "drilling, producing, gathering, storing, processing, refining, transferring, distributing or consuming oil and oil products. . . ." 40 C.F.R. § 112.1(b) (2002). None of these terms is a synonym for "using" oil and oil products.